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Sucrose Improves the Postharvest Life of Cut Flowers of a Hybrid *Limonium*

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***Abstract*. Regardless of their maturity at harvest, the vase life of cut inflorescences of the hybrid *Limonium* 'Fantasia' placed in deionized water was 4 to 5 days. A vase solution containing Physan (a quaternary ammonium disinfectant solution) at 200 µl·liter^{-1} and 20 g sucrose/liter not only prolonged the longevity of individual florets but also promoted bud opening so that the vase life of cut inflorescences extended to 17 days. Pulse treatment with 100 g sucrose/liter in combination with Physan at 200 µl·liter^{-1} for 12 hours partially substituted for a continuous supply of sucrose. Including 30 mg gibberellic acid/liter in the vase solution was without benefit.**

The *Limonium* cultivars Fantasia, Misty Blue, and Saint Pierre are interspecific hybrids between *L. bellidifolia* Gouan and *L. latifolium* Kuntzn. Under moderate growing temperatures (≈20C), the plants produce flower stalks bearing tiny blue flowers year-round.

The panicled compound racemes comprise numerous subspikes containing eight to 12 pairs of flower buds. One of the flower buds in each pair develops earlier than the other. The opening of the more mature flower buds in each pair proceeds from the base to the top of the subspike; then the less mature buds in each pair open in the same sequence. During maturation, the color of the inflorescence changes from green to white and then to blue because the calyces are white and the petals blue. As petals wilt and inroll, the color turns back to white.

The blue stage of the inflorescences, which is the most attractive in these hybrids, lasts for only a few days after harvest if the flowers are placed in plain water (A. Matsui, Matsui Nursery, personal communication). The short vase life of the cut inflorescences might reflect a failure in water relations or a failure of the unopened buds to develop. A similar situation occurs in cut gypsophila (*Gypsophila paniculata* L.), which also has numerous buds at different developmental stages. Marousky (1972) reported that effective flower opening, improved longevity, and increased turgidity was achieved in gypsophila by using a floral preservative containing 8-hydroxyquinoline citrate (8-HQC) and sucrose. The longevity of individual florets also was promoted by using a vase solution containing quaternary ammonium compounds, such as Physan (Maril Products, Tustin, Calif.) (Van Doorn and Reid, 1992), benzalkonium chloride, or lauryl dimethyl ammonium bromide (Tandler et al., 1986). Adding sucrose to these solutions improved bud opening and further extended vase life of inflorescences (Farnham et al., 1978; Tandler et al., 1986; Van Doorn and Reid, 1992). Presumably, these disinfectants improve the water conductance by preventing bacterial growth (Van Doorn and Perik, 1990; Van Doorn et al., 1991), and sucrose supplies the energy and carbon skeletons required for bud opening. In contrast, Steinitz and Cohen (1982) reported that applying a combination of sucrose with silver nitrate as a biocide had no effect on flower bud opening in the most common commercial *Limonium*, *L. sinuatum* L.; however, they found that gibberellic acid (GA_3) was effective in promoting petal expansion. Therefore, our objectives were to examine the effects of bactericides (Physan and 8-HQC), sucrose, and GA_3 on the longevity of the hybrid *Limonium* 'Fantasia' to develop a useful commercial means of extending the life of these attractive flowers.

Materials and Methods

Inflorescences of hybrid *Limonium* 'Fantasia', harvested with 5%, 15%, and 40% of their florets open, were harvested from a commercial greenhouse in Salinas, Calif., and immediately were transported dry to Davis, Calif., by air. Lateral branches from the harvested inflorescences were trimmed to 40 to 50 cm for use in experiments.

To examine the effect of components of the vase solution, cut inflorescences with 5%, 15%, and 40% of their florets open were recut under water and placed in deionized (DI) water containing Physan at 200 µl·liter^{-1} (the commercial 20% concentrate of Physan-20 at 1 ml·liter^{-1}) or 8-HQC at 200 mg·liter^{-1} with or without sucrose at 20 g·liter^{-1}. Physan 20 is a commercial mixture consisting of 10% *n*-alkyl (C_{12}-C_{14}) dimethylethylbenzyl ammonium chlorides and 10% *n*-alkyl (C_{12}-C_{14}) dimethylethylbenzyl ammonium chlorides. The vase solutions were adjusted to pH 4 with citrate–citric acid buffer and placed in sterile plastic bags in hard plastic holders covered with plastic caps. Uptake of vase solution was measured daily by weighing the vase solution and cut inflorescences separately. Evaporation from the solution was negligible. In another experiment, cut inflorescences with 5% of their florets open were placed in solutions containing GA_3 at 30 mg·liter^{-1} with or without Physan and sucrose at the concentrations previously noted.

The effects of pulse pretreatment with sucrose were examined by pretreating cut inflorescences for 12 h with DI water or with DI water containing Physan at 200 µl·liter^{-1} and sucrose at 100 g·liter^{-1}. After pretreatment, the stems were rinsed with DI water and placed in DI water or in a solution containing Physan at 200 µl·liter^{-1} and sucrose at 20 g·liter^{-1}.

All experiments were performed in a controlled environment at 20C and 60% relative humidity with 12-h lighting by cool-white fluorescent tubes (Phillips Lighting, Bloomfield, N.J.) providing photosynthetically active radiation (≈10 µmol·m^{-2}·s^{-1}) at plant height. The most recently opened floret on each subspike was tagged with colored cotton thread at the start of the experiment. The effect of treatments then was determined by measuring the longevity of the tagged florets and the number of florets that opened per subspike. The vase life of inflorescences was considered terminated when no open florets remained. Uptake of water was measured by periodically removing the inflorescence and weighing the vase. Each treatment was replicated five times.

Table 1. Effects of continuous application of Physan at 200 µl·liter^{-1} with or without sucrose at 20 g·liter^{-1} on longevity of individual florets and inflorescences of hybrid *Limonium* 'Fantasia' harvested at three maturities (expressed as a percentage of open florets).

Vase solution	Harvest maturity (% open)	Floret opening after harvest (no./subspike)	Longevity (days) Floret[z]	Longevity (days) Inflorescence
Deionized water	5	1.7 a[y]	2.9 a	4.1 a
	15	---[x]	---	5.3 a
	40	---	---	5.1 a
Physan	5	1.7 a	2.7 a	5.2 a
Physan/sucrose	5	7.5 b	4.1 b	16.7 b
	15	---	---	17.1 b
	40	---	---	16.9 b

[z]Longevity of first open florets on a subspike.
[y]Mean separation in columns by Duncan's multiple range test at $P \leq 0.05$.
[x]Data not collected.

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Data were subjected to regression analysis or analysis of variance, and means were separated using Duncan's multiple range test at $P \leq 0.05$.

Results and Discussion

Regardless of their harvest maturity, the longevity of cut 'Fantasia' inflorescences held in DI water averaged 5 days, and only one or two florets opened on each subspike during the postharvest period (Table 1). This short inflorescence life was due mainly to failure of bud opening and partly to the short longevity of individual florets. Adding Physan to the vase solution improved the water uptake (Fig. 1) but had no marked effect on bud opening or inflorescence longevity. The presence of 2% sucrose in the vase solution promoted bud opening and dramatically increased the life of cut inflorescences to 17 days. Immature flower buds, even on inflorescences harvested with only 5% open florets, developed and opened. When 8-HQC was used as a bactericide instead of Physan, similar results were obtained, but the biocide caused severe stem yellowing (data not shown). These data indicate that it is sucrose, not the biocide per se, that promotes opening and extends the vase life of *Limonium* 'Fantasia'.

The supply of sugars to cut flowers promotes bud opening and retards flower senescence. Such effects have been reported for gladiolus (*Gladiolus* ×*hortulanus*) (Kofranek and Halevy, 1976), spray carnations (*Dianthus caryophyllus*) (Borochov and Mayak, 1984), gypsophila (Downs et al., 1988), and liatris (Han, 1992). In cut flowers bearing florets that develop sequentially, there is competition among florets for the available carbohydrate. Immature flower buds fail to develop without an additional carbohydrate supply. In hybrid *Limonium* 'Fantasia', harvest resulted in cessation of flower bud opening and applying sucrose was essential to continued bud opening. Sucrose treatment also increased the longevity of individual florets, perhaps by increasing the pool of respiratory substrate and lowering the osmotic potential of the petals (Halevy and Mayak, 1979).

In cut roses (*Rosa hybrida* L.), sucrose in the vase solution may reduce water uptake (Durkin, 1979). In 'Fantasia' inflorescences, sucrose had a small positive effect on water uptake rates (Fig. 1), perhaps reflecting water needed for floret expansion and the increased transpiration surface of the petals on open flowers. Treating 'Fantasia' inflorescences with GA_3 did not improve bud opening as reported for *L. sinuatum* by Steinitz and Cohen (1982). GA_3 accelerated petal desiccation in open flowers, resulting in decreased inflorescence life (data not shown).

The longevity of cut inflorescences pretreated for 12 h with Physan at 200 µl·liter^{-1} + sucrose at 100 g·liter^{-1} was 9.6 days when they subsequently were placed in DI water continuously and nearly twice as long when they were held in a vase solution containing Physan at 200 µl·liter^{-1} + sucrose at 20 g·liter^{-1} (Table 2). Thus, the pulse treatment was not as effective as continuous application but certainly provided a commercially useful increase in vase life. Presumably, the total amount of sucrose absorbed by inflorescences during the postharvest period was greater when sucrose was continuously applied at a low concentration than when it was provided as a high-concentration (10%) pulse. The intermediate vase life (15 days) of flowers that were not pulsed but held in Physan at 200 µl·liter^{-1} + sucrose at 20 g·liter^{-1} indicates that a pulse pretreatment always would be useful. In cut carnations (*Dianthus caryophyllus* L.), the beneficial effects of sucrose include reduced petal sensitivity to ethylene, which delays the onset of climacteric ethylene production and senescence (Mayak and Dilley, 1976). The possible role of ethylene in the senescence of hybrid *Limonium* flowers requires study.

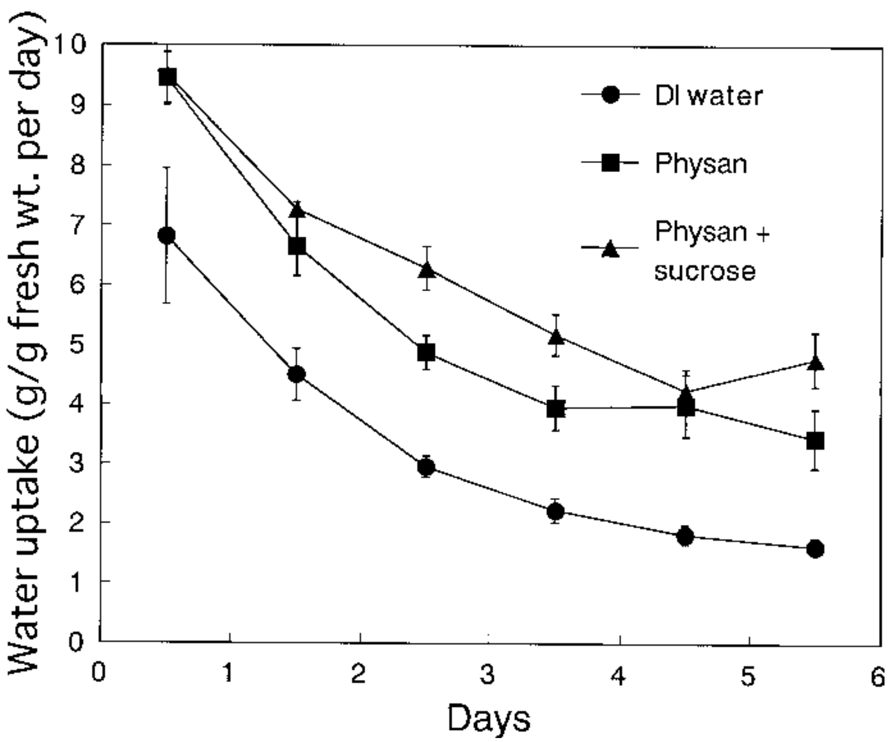

Fig. 1. Uptake of vase solutions by cut inflorescences of hybrid *Limonium* 'Fantasia' placed in deionized (DI) water or a solution containing Physan at 200 µl·liter^{-1} with or without sucrose at 20 g·liter^{-1}. Vertical bars are the SE of five replicate measurements at each time point. Regression analysis of the data gave the following regression equations:
DI water, $y = 0.27x^2 - 2.61x + 7.95$ ($r^2 = 0.995$).
Physan, $y = 0.33x^2 - 3.09x + 10.7$ ($r^2 = 0.984$)
Physan + sucrose, $y = 0.25x^2 - 2.47x + 10.6$ ($r^2 = 0.985$).

Table 2. Effects of a 12-h pulse treatment with sucrose at 100 g·liter^{-1} containing Physan at 200 µl·liter^{-1} on the longevity of individual florets and inflorescences of hybrid *Limonium* 'Fantasia' harvested with 40% of their florets open. After the pulse treatment, the flowers were placed in deionized (DI) water or DI water containing sucrose at 20 g·liter^{-1} and Physan at 200 µl·liter^{-1}.

Pretreatment solution	Vase solution	Floret opening after harvest (no./subspike)	Longevity: Floret[z]	Longevity: Inflorescence
DI water	DI water	2.0 a[y]	2.5 b	4.4 a
Physan/sucrose	DI water	3.7 b	3.2 b	9.6 b
DI water	Physan/sucrose	7.5 c	3.8 b	14.6 c
Physan/sucrose	Physan/sucrose	10.2 d	3.5 b	18.0 d

[z]Longevity of first open florets on a subspike.
[y]Mean separation in columns by Duncan's multiple range test at $P \leq 0.05$.

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